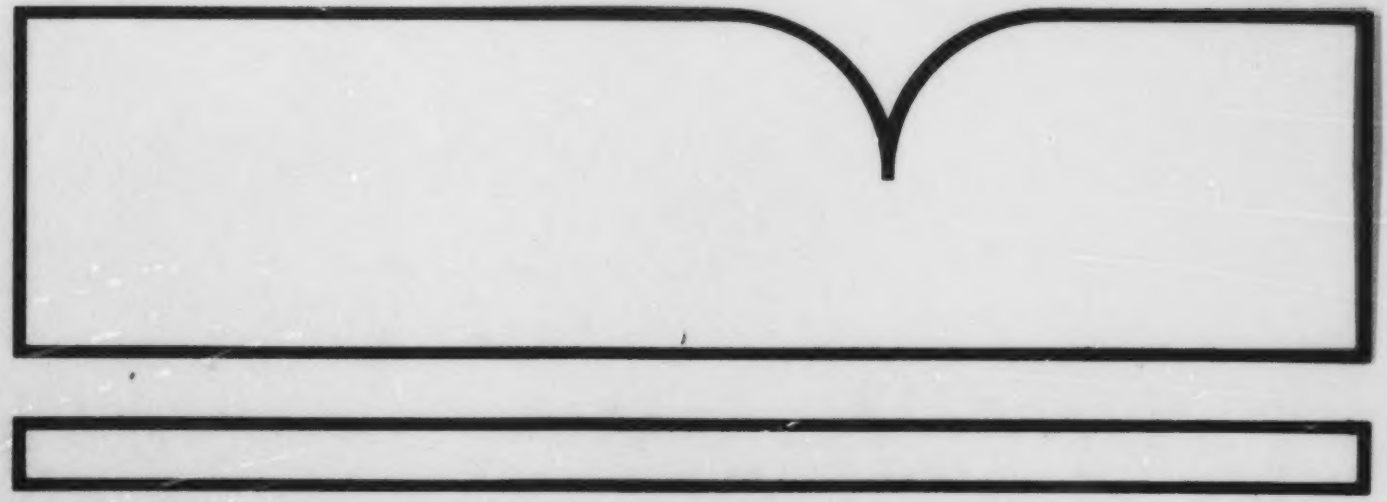
PB84-168673

Results of the Initial Trial Burn of the EPA-ORD (Environmental Protection Agency Office of Research and Development) Mobile Incineration System

(U.S.) Municipal Environmental Research Lab.
Edison, NJ

1984



U.S. Department of Commerce
National Technical Information Service
NTIS

PB84-168673

EPA-600/D-84-088
1984

RESULTS OF THE INITIAL TRIAL BURN OF THE EPA-ORD MOBILE INCINERATION SYSTEM

by

James J. Yezzi, Jr., John E. Brugger, Ira Wilder, and Frank Freestone
Oil & Hazardous Materials Spills Branch
Municipal Environmental Research Laboratory
U.S. Environmental Protection Agency
Edison, New Jersey

Richard A. Miller, Charles Pfrommer, Jr., and Ralph Lovell
IT Corporation
Edison, New Jersey

EPA Contract 68-03-3069

EPA Project Officer
James J. Yezzi, Jr.

MUNICIPAL ENVIRONMENTAL RESEARCH LABORATORY
OFFICE OF RESEARCH AND DEVELOPMENT
U.S. ENVIRONMENTAL PROTECTION AGENCY
CINCINNATI, OH 45268

REPRODUCED BY
NATIONAL TECHNICAL
INFORMATION SERVICE
U.S. DEPARTMENT OF COMMERCE
SPRINGFIELD, VA. 22161

TECHNICAL REPORT DATA
(Please read Instructions on the reverse before completing)

1. REPORT NO.	2.	3. RECIPIENT'S ACCESSION NO.
EPA-600/D-84-088		PB84-168673

4. TITLE AND SUBTITLE	5. REPORT DATE
RESULTS OF THE INITIAL TRIAL BURN OF THE EPA-ORD MOBILE INCINERATION SYSTEM	1984
	6. PERFORMING ORGANIZATION CODE
7. AUTHOR(S)	8. PERFORMING ORGANIZATION REPORT NO.
J. Yezzi, J. Brugger, I. Wilder, F. Freestone, R. Miller, C. Pfrommer, and R. Lovell	
9. PERFORMING ORGANIZATION NAME AND ADDRESS	10. PROGRAM ELEMENT NO.
IT Enviroscience 312 Directors Drive Knoxville, TN 37923	TE1Y1A
	11. CONTRACT/GRANT NO.
	68-03-3069
12. SPONSORING AGENCY NAME AND ADDRESS	13. TYPE OF REPORT AND PERIOD COVERED
Municipal Environmental Research Laboratory--Cin., OH Office of Research and Development U.S. Environmental Protection Agency Cincinnati, OH 45268	14. SPONSORING AGENCY CODE EPA/600/14

15. SUPPLEMENTARY NOTES

Project Officer: J. Yezzi, Jr. (201-321-6703

16. ABSTRACT

This paper discusses the sampling and analytical methods for, the implementation of, and the results of the initial trial burn conducted with the EPA-ORD Mobile Incineration System. The system was developed to destroy hazardous substances and toxic wastes on site. The trial burn program consisted of five tests with different liquid feeds, (including tetrachloromethane and PCBs) to evaluate the system's capability for destroying organic hazardous substances while controlling emissions of HCl, particulate matter, and hydrocarbons in compliance with the requirements of the Federal RCRA and TSCA, as well as those of the New Jersey Department of Environmental Protection.

17. KEY WORDS AND DOCUMENT ANALYSIS

a. DESCRIPTORS	b. IDENTIFIERS/OPEN ENDED TERMS	c. COSATI Field/Group

18. DISTRIBUTION STATEMENT	19. SECURITY CLASS *(This Report)*	21. NO. OF PAGES
RELEASE TO PUBLIC	UNCLASSIFIED	36
	20. SECURITY CLASS *(This page)*	22. PRICE
	UNCLASSIFIED	

EPA Form 2220-1 (9-73)

RESULTS OF THE INITIAL TRIAL BURN OF THE EPA-ORD MOBILE INCINERATION SYSTEM

James J. Yezzi, Jr., John E. Brugger, Ira Wilder, and Frank Freestone
Oil & Hazardous Materials Spills Branch
Municipal Environmental Research Laboratory
U.S. Environmental Protection Agency
Edison, New Jersey

Richard A. Miller, Charles Pfrommer, Jr., and Ralph Lovell
IT Corporation
Edison, New Jersey

ABSTRACT

This paper discusses the sampling and analytical methods for, the implementation of, and the results of the initial trial burn conducted with the EPA-ORD Mobile Incineration System. The system was developed to destroy hazardous substances and toxic wastes on site. The trial burn program consisted of five tests with different liquid feeds, including tetrachloromethane and polychlorinated biphenyls (PCBs), to evaluate the system's capability for destroying organic hazardous substances while controlling emissions of HCl, particulate matter, and hydrocarbons in compliance with the requirements of the Federal Resource Conservation and Recovery Act (RCRA) and Toxic Substances Control Act (TSCA), as well as those of the New Jersey Department of Environmental Protection.

INTRODUCTION

The EPA's Office of Research and Development sponsored the development of the Mobile Incineration System through its Oil and Hazardous Materials Spills (OHMS) Branch located in Edison, New Jersey. The system was designed and constructed under contracts with MB Associates, Mason & Hanger-Silas Mason Company, Inc., and IT Enviroscience. Testing and operation of the system is conducted by the OHMS Branch Environmental Emergency Response Unit (EERU); the EERU contract is presently conducted by IT Enviroscience, Knoxville, TN.

NOTICE

This document has been reviewed in accordance with U.S. Environmental Protection Agency policy and approved for publication. Mention of trade names or commercial products does not constitute endorsement or recommendation for use.

The function of the Mobile Incineration System is to demonstrate the ability of on-site thermal destruction of hazardous and toxic organic substances at various spill or disposal sites. Since incineration of hazardous substances is regulated by federal and state agencies, a trial burn plan was developed to comply with the applicable regulations and to establish the performance capability of the system in destroying/detoxifying hazardous and toxic organic chemicals and wastes. The plan consisted of five trial burn tests that were conducted in three phases from September, 1982 through January, 1983 at the EPA-EERU facility in Edison, NJ. The tests evaluated the ability of the Mobile Incineration System to destroy tetrachloromethane (carbon tetrachloride), dichlorobenzene, trichlorobenzenes, tetrachlorobenzenes, and PCBs while controlling the emission of HCl and particulate matter. A total of 25 test runs were conducted during which the incinerator's operating conditions were monitored and an extensive sampling and analytical program was conducted. Federal and state observers were on site throughout the entire trial burn to ensure that the incineration system was operated safely and in accordance with the trial burn permits.

Since a trial burn of hazardous and toxic substances cannot be conducted without the approval of the various federal and state permitting agencies, applications were submitted for the federal and state permits listed in Table 1. Although municipal or local permits were not required for the trial burn, such permits may be necessary when the system is utilized at other sites.

SYSTEM DESCRIPTION

The complete Mobile Incineration System consists of three major subsystems: 1) combustion and air pollution control (APC) equipment mounted on three trailers, 2) continuous flue gas monitoring equipment located in a fourth trailer, and 3) support equipment. The major system components are identified in a block flow diagram (Figure 1), and the design specifications are shown in Figure 2. A detailed description of the Mobile Incineration System has been published (Yezzi, et al.[1]).

Briefly, the incineration system consists of a primary combustion chamber (rotary kiln) where solid or liquid wastes are introduced, volatilized, and partly oxidized and a clean fuel oil-fired secondary combustion chamber (SCC) for completing the combustion process initiated in the kiln. The combustion flue gases pass through a gas cleaning unit designed to collect and remove particulate matter and acid gases prior to discharge through the stack. The initial treatment of the combustion gases is accomplished by water quenching in the quench elbow, which is then followed by particulate removal in a cleanable high efficiency air filter (CHEAF). (The primary function of the elbow is to lower the gas temperature from 1200°C (2200°F) to adiabatic saturation, approximately 85°C (185°F), and thus reduce the gas volume; some particulate and acid gas removal does occur in the quench elbow.) The final step in the gas treatment process is the removal of acid gases in a cross-flow packed-bed mass-transfer scrubber. The pH of each process water stream is controlled by the addition of sodium carbonate to enhance acid gas removal and to minimize corrosion of the gas cleaning equipment. The prime gas mover for the incineration system is a diesel-powered induced-draft fan that maintains a negative pressure in the entire system so as to prevent the leakage of toxic vapors. The process gas is discharged through a 12 m (40 ft) stack.

Combustion efficiency and stack emissions are continuously monitored by analyzers that measure the concentration of O_2, CO_2, CO, total hydrocarbons (THC), SO_2, and NO_x in the flue gas from the SCC and in the stack. The gas monitoring system is described in detail (Brugger, et al.[2]). Basically, the system collects samples from the incineration process at two locations (the SCC and the stack), and transports the conditioned (filtered, cooled, and dried) gaseous samples to two gas chromatographs and a chemiluminescent detector for analysis. The complete analysis of each sample requires five minutes; the results are printed out on a computer terminal. The continuous monitors are an integral part of the safety interlock system that automatically stops the feed of hazardous materials when any aspect of the incineration process deviates from the normal or regulation-required operating ranges.

Since the Mobile Incineration System is designed to operate at remote sites, field support equipment was used during the trial burn to generate process utilities (power, steam, and compressed air) and to provide tankage for the preparation and feed of waste liquids and alkaline scrubbing solution (see Figure 3). All electrical power required to illuminate the work area and to operate the incineration system, the personnel facilities, and the mobile analytical laboratory was provided by two diesel-powered generators. A small, diesel-fired boiler generated steam was used to atomize the water injected into the rotary kiln and to operate the sample eductors for the continuous monitoring system. Compressed air for atomization of the waste oil injected into the rotary kiln and for various instrument requirements was provided by a diesel-powered air compressor. Diesel fuel required to power the utility generators and to provide auxiliary fuel for the incineration system was stored in a diked tanker, which was refilled by a local fuel oil supplier on a regular basis.

Simulated waste oil mixtures for the tests were prepared by mixing specified quantities of the test compounds and diesel fuel in a sealed, agitated vessel prior to each test run. The mixture was then pumped through a mass flowmeter directly into the rotary kiln. The waste feed system was designed and operated as a closed system to minimize the exposure of operating personnel to hazardous materials. The waste feed area was designed to fulfill federal and state requirements that govern the storage of hazardous and toxic substances.

The alkaline scrubbing solution, used to neutralize acid gases in the air pollution control equipment, was prepared in two agitated tanks by mixing sodium carbonate with water to form a 6% solution. Spent process water from the incineration system was pumped into a holding tank for sampling and for measuring pH and temperature prior to discharge into a storm sewer. (At the operating pH of ca. 9, the actual scrubbing solution is chiefly sodium bicarbonate, which is formed by the reaction of CO_2 (an acid) in the flue gas with the sodium carbonate solution.)

The sampling and analytical crews used two mobile laboratories, one for the preparation and disassembly of stack gas sampling equipment and the

other for the on-site analysis of ambient air samples and for the initial preparation of test samples for analysis. Operating personnel required an additional trailer for a lunchroom and for holding safety meetings, which were conducted at the beginning of each shift.

Safety equipment, including temperature-controlled eye baths and safety showers, fire extinguishers, first aid equipment, and an evacuation alarm system, was placed at strategic locations around the test site. Spill control equipment, such as foam dike packs, shovels, sorbents and spill clean-up blankets, was available in the event of a fuel oil or hazardous substance spill. Personnel protection equipment for routine operation, as well as for special situations (handling of the hazardous and toxic test materials), was available and utilized during the trial burn.

TRIAL BURN PLAN

Federal and State regulations require that incinerator performance data be submitted before operating permits will be issued. These data are collected during a series of specified trial burn tests by monitoring operating conditions and collecting samples of feed and effluent streams for analysis. The test series, or trial burn, is designed to demonstrate compliance with applicable regulations and establish the operating conditions that will eventually become the bases for operating permits. The trial burn for the Mobile Incineration System was initially designed to demonstrate the capability of the system to incinerate PCBs and other hazardous organic compounds, while controlling particulate matter and hydrogen chloride (HCl) emissions in accordance with TSCA and RCRA, at the stringent operating conditions specified by TSCA for incinerating PCBs. After the initial baseline testing was completed (Phase I), the trial burn plan was modified for Phase II to include tetrachloromethane (CCl_4) which is considered to be one of the most difficult materials to incinerate according to the RCRA ranking of hazardous substances. The successful incineration of CCl_4 during the trial burn would thus allow the issuance of a RCRA permit to incinerate almost all RCRA-regulated organics. The trial burn consisted of five tests, each with a different feed mixture, grouped into three test phases as shown in Table 2.

Phase I consisted of Test 1, which provided baseline operating and performance data through the burning of clean (<0.2% sulfur and no organohalogens) diesel fuel only. Phase II consisted of Tests 2 and 3, designed to measure the particulate matter removal efficiency of the air pollution control (APC) equipment, the HCl removal efficiency of the APC equipment, and the destruction and removal efficiency (DRE) of CCl_4 and o-dichlorobenzene (ODCB), both RCRA-regulated organics. Phase III consisted of Tests 4 and 5 where the DREs of two different concentrations of "Askarel"*, a PCB/trichlorobenzene mixture, were measured along with the particulate matter and HCl removal efficiencies of the APC. All organic DRE tests and particulate matter removal tests were run in triplicate in accordance with federal and state requirements. Additional particulate matter removal tests were conducted to satisfy New Jersey Department of Environmental Protection (NJDEP) requirements for incineration systems.

SAMPLING AND ANALYTICAL METHODS

A critical aspect of any test program is the selection of sampling locations and the methods used to obtain accurate data on the operating conditions and performance of the equipment being tested. The sampling program designed for the mobile incinerator trial burn had to: (1) meet the needs of regulatory agencies that reviewed the system's compliance with state and federal statutes and (2) provide operating engineering data for the continued development and demonstration of mobile incineration technology. These needs were met by sampling all feed and discharge streams (solid, liquid, or gaseous) during test runs. The methods used to sample the various process streams ranged from simply filling a sample bottle with make-up water to the operation of an EPA Modified Method 5 sampling train capable of collecting micrograms of PCBs and other organics. Sampling locations, methods, and frequency are summarized in Table 3.

* The mention of the trade names or commercial products does not constitute endorsement or recommendation for use by EPA or IT Corporation.

The samples collected during the trial burn were analyzed according to methods listed in Table 4. Many of these methods are "Standard Methods" as described in the Federal Register, EPA Reports, or other references. Some of the methods, such as the methodology for analysis of polychlorinated dibenzo-p-dioxins, were non-standard methods that will be described in detail in an EPA research and development technical report to be issued in the future.

SYSTEM OPERATION

Experimental Procedure

The same operating procedures were used for conducting each of the trial burn tests. The test feed mixtures were prepared by adding a specified quantity of the test compounds into the waste feed tank along with enough clean diesel fuel to make the desired blend. The tank agitator was operated to mix the components; agitation was maintained throughout the test to ensure a uniform feed mixture. The incineration system was kept hot, > 815°C (>1500° F), between testing and was brought up to the desired operating conditions prior to each test with clean diesel oil as the fuel. The flow of test material was gradually increased as the fuel oil flow was reduced. Once the desired feed rate of test materials was attained, the incineration system was operated for a minimum of one hour at test conditions to ensure that the system had come to a steady state before sampling was initiated. The incineration system was then maintained at these conditions throughout the testing period. At the conclusion of the day's testing, the feed to the incineration system was switched from the test material to clean diesel fuel. The required test mixture was prepared at night for the next day's test run.

Operating Conditions

The Mobile Incineration System was operated at the conditions specified in the federal and state trial burn permits. These conditions were specified not only for the combustion chambers, but also for the components of the APC system (i.e., quench sump liquid level). The

actual operating conditions for the combustion chambers are shown in Table 5. The gas retention times and excess air levels for each chamber are calculated values based on the measured flow rates of the feed streams.

The retention times calculated by this method do not include infiltration air, but the quantity of infiltration air is believed to be low in relation to combustion air because of the types of seals and the tightness of the system. The major air infiltration source on the incineration system is in the CHEAF, which is downstream of the combustion chambers. Air inleakage at this point significantly alters gas flowrates and concentrations of combustion gas components. For this reason, calculation of combustion chamber gas retention times was based on feed stream flow rates rather than on stack flow measurements.

Operational Problems Encountered

Prior to initiation of the trial burn, the Mobile Incineration System underwent two shakedown runs, one in October, 1981 and the other in April, 1982. During each shakedown, the system was operated at design conditions using diesel fuel only; the mechanical and process performance of each component in the system was observed and evaluated within the limitations imposed by only burning fuel oil. As with any new process, especially prototypes, various problems were encountered. Several notable difficulties were experienced during the first shakedown run (e.g., it was difficult to achieve and to maintain the design operating temperature in the secondary combustion chamber) that prevented the evaluation of some of the more sensitive process controls. The system was modified for re-evaluation during the second shakedown run.

The results of the second shakedown operation were much more encouraging, but some minor problems were encountered that had been masked by the more major problems of the initial shakedown. Additional modifications were made to the system to correct these problems; however, these alterations could not be evaluated until the first phase of the trial burn test. Authorization was requested from the regulatory agencies to allow the startup of the system several days in advance of the Phase I of the trial

burn test -- in order to conduct a shakedown and evaluation that would ensure that the system was running smoothly; however, approval was denied. Consequently, subsequent to the initiation of the trial burn, several days were spent in stabilizing and refining various process controls and correcting minor mechanical problems. These corrections and adjustments delayed the first phase of the trial burn.

During the first two phases of the trial burn, various problems were encountered, most of which were resolved quickly. Discussions of the more significant problems follows:

1. The flow pattern in the stack was somewhat uneven in that most of the flow was preferentially along one side of the 0.6-m (2-ft) square stack. The difference in flow from one side to the other was greater than the range of a single MM5 probe tip for collecting isokinetic samples. Since the regulatory agencies would not allow the probe tip to be changed during sampling, the flow difference had to be corrected. The major factor affecting the flow profile appared to be the recycling of a portion of the stack gas back to the CHEAF through the reflow duct. When the reflow duct was blanked off, the flow in the stack was still uneven but within the range of the sampling probe tip. Despite the uneven flow, cyclonic conditions did not exist at the sampling location.

2. The filtering (fine particulate matter removal) mechanism of the CHEAF is a glass fiber mat through which the flue gases pass. A nominal 7.5-kPa (30-in. WC) pressure differential is maintained across the mat, which is supported by an Inconel chain belt. As the mat collects particles and becomes plugged, a pressure differential switch automatically advances the mat through the unit. Water is sprayed onto the mat to keep it clean by dissolving soluble particulate matter.

   Since the fuel and test materials fed into the incinerator were free from ash and other particulate generating components excepting the slight quantity of ablated refractory dust and the iron oxide particles that were utilized during Test 2 -- the mat did not become

plugged. As a result the mat did not advance and therefore the water sprays tended to erode holes through the mat after striking the same spot over a long time period. The development of holes reduced the pressure differential and activated an interlock that shut down the whole incineration system. This problem was corrected by installing a variable-timer which automatically advanced the mat before holes developed.

3. The continuous stack monitoring system was initially evaluated during the second shakedown test and was also operated for extended periods independent of the incinerator operation. Some unexpected problems occurred during the trial burn tests.

The most significant problem arose when a condensate trap in the sampling assembly did not drain properly. As a result, water (or condensate) entered the combustion gas sample line and passed into the analytical system. This problem existed throughout Phase II and frequently resulted in the automatic shut down of the monitoring system. The problem was eventually traced to a loose wire connection in the controls of the automatic drain system on the condensate trap.

The ceramic probe used for sampling the secondary combustion chamber flue gas, cracked or broke several times during the trial burn. In order to keep the system operating during the trial burn, stainless steel probe tips were field-fabricated and fastened to the ceramic probe base assembly whenever a replacement tip was required. A ceramic-free Inconel probe will be fabricated and used in the future.

The microprocessors which controlled the monitoring system failed several times, because of the electrical failure of an internal component. Since the monitoring of CO, CO_2, and O_2 are required by federal and state regulations, the trial burn had to be halted whenever the monitoring system failed; testing was resumed when the fault was corrected. Many hours of delay were caused by the various monitoring problems. The monitoring system required the most attention during the trial burn with much effort being expended on

making repairs and on recalibrating (at night) between the trial burn tests.

4. There was no way to test the performance of the APC section for acid gas removal before the trial burn, because the regulatory agencies would not allow the system to be tested with hydrochloric acid (HCl) gas prior to the trial burn unless a special permit was obtained -- a step that would have delayed tests for many months. Several problems occurred when the highly chlorinated materials of Test 3 were first fed into the incinerator. An immediate problem was that the quench recycle pump lost its suction head and the resultant loss of recycle flow caused automatic shut down of the incineration system. Because of the overall vacuum (negative pressure) in the system, the suction head of the pump is barely adequate to maintain flow under normal conditions; the release of CO_2 from the reaction of the HCl with the $NaHCO_3/Na_2CO_3$ in the scrubbing solution was sufficient to reduce the head to the extent that pumping failed (i.e., cavitation occurred). This problem was alleviated by enlarging the suction piping and adding an external surge tank; however, the immediate corrective action that was taken was starting the feed of chlorinated material slowly, so as to eliminate generation of sudden surges of HCl and subsequently, CO_2. The suction head cannot be increased unless the pump is placed in a depression whenever the mobile incinerator is set up.

Instrument quality compressed air is used to activate the pH-controlled automatic valves on the alkaline solution piping into the quench, CHEAF, and MX scrubber. Since little acid gas is generated by fuel oil, these valves seldom operated prior to the feeding of the nonchlorinated organics. However, when the APC section encountered high HCl loadings, these valves operated frequently. This caused air pressure reduction, followed by pressure surges, to several instruments -- some of which were safety interlocks that responded by shutting down the incineration system. This problem was corrected by installing separate air lines from the air compressor for the instruments and for the automatic valves.

TRIAL BURN RESULTS

The test results from the trial burn can be understood by evaluating five principal performance criteria: (1) particulate matter removal efficiency, (2) HCl removal efficiency, (3) organic destruction and removal efficiency, (4) waste water quality, and (5) ambient air quality. The first three criteria apply to the major emissions from the stack of the Mobile Incineration System. These three criteria, in addition to waste water quality, are closely monitored to ensure compliance with state and federal regulations. The fifth criterion, ambient air quality, is important from a socio-political point of view relative to the citizens in the local community. These performance criteria will be discussed in terms of the stack emissions, waste water quality, and monitoring systems.

Stack Emissions

Stack emissions from incineration processes are heavily regulated and were the most scrutinized part of the process during the mobile incineration system trial burn. The performance of all major systems (combustion chambers for organic destruction and APC equipment for cleaning the combustion gases) was measured by comparing the quantity of material fed to the incineration system to the quantity emitted from the stack. These comparisons are shown in Tables 6 and 7 for tests 2 through 5. The mass flowrate of the test compound in the waste feed and the stack gas emission rate provides the basis for calculating HCl removal efficiency and organic DRE. The requirements specified by RCRA are: (1) maximum allowable particulate matter emission rate of 180 mg/m^3 when corrected to 7% oxygen in the stack gas; (2) HCl removal of 99% or a release of 1.8 kg/hr (4 lb/hr) for the stack emission, whichever is greater; and (3) minimum organic DRE (i.e., for tetrachloromethane, trichlorobenzenes, and tetrachlorobenzenes) of 99.99%. During all trial burn tests, the system performance met the requirements for each of these criteria.

Wastewater Quality

The wastewater from the incineration process was analyzed for TOC, pH, temperature, total dissolved solids, total suspended solids, petroleum hydrocarbons, volatile organics, and the test organic compounds. The results of hourly, daily, and weekly sampling and analysis of the wastewater are summarized in Table 8. The concentration of the test organics in the wastewater was lower than 20 µg/L (ppb) (i.e., limit of detection) during the entire trial burn. The main contaminants in the wastewater were dissolved salts from the neutralization of acid gases (HCl and fuel-oil derived SO_2) with scrubbing solution (sodium bicarbonate and carbonate).

Monitoring Systems

Three monitoring programs were conducted concurrently during the trial burn tests -- personnel, site and process. Personnel and site monitoring, focused on measuring the impact of fugitive and stack emissions on the operating personnel and ambient air quality. The third program, process monitoring, included the monitoring of all instrumentation including the continuous stack gas monitoring that is used to measure the combustion efficiency and stack emissions of the incinerator in accordance with federal and state regulations

The personnel and site monitoring programs consisted of air samples being collected in the immediate vicinity of the mobile incinerator (see Figure 4), and around the test site to measure the impact of the stack and fugitive emissions on the air quality. Data from personnel monitoring stations, shown in Table 9, indicated low levels of trichlorobenzene and tetrachlorobenzene near the waste feed tank and rotary kiln. No evidence of PCBs were found in any personnel monitoring samples. The concentration of chlorobenzenes measured is much lower than the level considered to be an industrial hygiene hazard.

The site monitoring program collected ambient air 0.3 to 1.0 km (0.2 to 0.6 miles) downwind from the incinerator stack (see Figure 5). No measurable quantities of chlorobenzenes or PCBs were detected. The

detection level for both trichlorobenzene and tetrachlorobenzene was 0.1 $\mu g/m^3$ and for PCBs (as Aroclor 1260) was 1.0 $\mu g/m^3$. These data verify the conclusions of an EPA air dispersion modeling evaluation (conducted prior to the trial burn) which indicated that the mobile incinerator would not adversely impact the quality of air in the local community.

The ability of the combustion and stack gas monitoring system to generate accurate and reproducable data was determined by performing extensive calibration checks with certified gas standards. These calibration checks were run on a daily basis throughout the trial burn. The results of the calibration checks, shown in Table 10, indicate that the analysis of O_2 and CO_2 were both accurate and precise. The less than 1 ppm of CO and THC measured in the SCC flue and stack gas is a concentration below the useable sensitivity of the analyzers, so calibration at 1-2 ppm had small absolute error (i.e., 0.5 ppm), but large relative error, 25%. For this reason the analysis accuracy and precision are shown in Table 10 for all calibrations and for all calibrations greater than 3 ppm.

A second measure of the quality of data reported by the continuous monitoring sysetm was made by the analysis of certified gas standards from a different gas supplier. The certified concentrations of the gas mixtures were unknown by the monitoring system operator and were analyzed as blind-audit samples. The average results of the monitoring system audits, shown in Table 11, support the conclusion that the continous monitoring system provides accurate gas analyses.

SUMMARY

Based on the high combustion and destruction efficiencies measured during the trial burn, the EPA Mobile Incineration System is an effective implement for the destruction of hazardous organic materials. In fact, the level of combustion and destruction reported was essentially based on analytical limitations of measurement rather than on the actual finding of hazardous components in the stack emissions. The results of the trial

burn indicate that the system met or exceeded all applicable federal requirements for incineration systems. The system met New Jersey State regulations but the state results are not reported herein due to the uniqueness of the state requirements and trial burn methodologies.

The initial function of the trial burn was to provide research and development data on the prototypical Mobile Incineration System; however, the requirements and requests of the state and federal regulations and regulatory agencies greatly expanded the expense and time frame for conducting the trial burn. Obtaining the necessary regulatory approvals to conduct the trial burn required over two years of effort and the resulting permitting and trial burn expense exceeded $1.5 million. Over 10,000 pages of log sheets, chromatograms, calibrations, and results tables were generated from the trial burn. Obviously, the results and discussion in this paper represent only a small fraction of that created from the 25 test runs conducted.

ACKNOWLEDGEMENTS

The authors gratefully acknowledge the dedication and effort of the operating crew from the EPA Environmental Emergency Response Unit (EERU) and IT Enviroscience, the sampling and analytical crews from A. D. Little Inc., York Research Corp. and IT Analytical Services, and the regulatory compliance review personnel from the New Jersey Department of Environmental Protection and the U.S. Environmental Protection Agency Region II.

REFERENCES

1. Yezzi, Jr., J. J., et al., "The EPA-ORD Mobile Incineration System," Proceedings of the 1982 National Waste Processing Conference, ASME, pp. 199-212.

2. Brugger, J. E., et al., "The EPA-ORD Mobile Incineration System: Present Status", 1982 Hazardous Material Spills Conference, pp. 116-126.

TABLE 1. PERMIT REQUIREMENTS FOR OPERATION OF MOBILE INCINERATION SYSTEM

Federal Permits	State Permits
Clean Air Act (CAA)	Bureau of Air Pollution Control Certificate to Operate
Toxic Substances Control Act (TSCA)	New Jersey Pollutant Discharge Elimination Systems Permits (NJPDES)
National Environmental Policy Act (NEPA)	Hazardous Waste Facility Registration Requirement Report
Resource Conservation and Recovery Act (RCRA)	Division of Hazard Management Permit
National Pollutant Discharge Elimination System (NPDES)	

Note: See Yezzi, et al.[1] for the specific source of each act and regulation.

TABLE 2. TRIAL BURN TEST SUMMARY

Test No.	Phase No.	Feed Material	Number of Runs	Test Purpose
1	I	Diesel fuel	2 DRE[a] 2 Particulate[b]	Baseline performance.
2	II	1.2% Fe_2O_3 [c] 98.8% Diesel fuel	3 Particulate	Particulate removal efficiency of APC.
3	II	21.4% CCl_4 [d] 28.9% $C_6H_4Cl_2$ [e] 49.7% Diesel fuel	3 DRE 3 Particulate	Destruction of RCRA organic; HCl removal efficiency of APC.
4	III	11.4% Askarel[f] 88.6% Diesel fuel	3 DRE 3 Particulate	Destruction of PCB (TSCA); HCl removal efficiency of APC.
5	III	39.3% Askarel[f] 60.7% Diesel fuel	3 DRE 3 Particulate	Destruction of PCB; HCl removal efficiency of APC.

a - Destruction and removal efficiency of principal organics.
b - NJDEP Incineration Test Method.
c - Iron oxide.
d - Carbon tetrachloride or tetrachloromethane.
e - Ortho-dichlorobenzene or 1,2-dichlorobenzene.
f - 58.9% Aroclor 1260, 35.0% trichlorobenzenes, 6.1% tetrachlorobenzenes.

NOTE: All compositions are reported on a wt/wt basis.

TABLE 3. SAMPLING PROGRAM FOR TRIAL BURN

SAMPLE	SAMPLING METHOD AND FREQUENCY	ANALYSIS
Waste Feed	One Composite Sample per Run (3 Grabs)	Elemental (C, H, O, N, S, Organic Cl), Density, Ash, Moisture
		Concentration of POHCs[a]
	One Sample per Test	Presence of PCDD[b], PCDF[c]
Diesel Fuel	One Composite Sample per Lot	Elemental (C, H, O, N, S, Organic Cl) Density, Ash, Moisture
Make-up Water	One Sample per Test Phase	Presence of POHCs, PICs[d]
Alkaline Scrubber Solution	One Composite Sample per Test Phase	Presence of POHCs, PICs
Purge Water	One Composite Sample per DRE run,	Presence of POHCs, PICs
	One Sample per Test	Presence of PCDD, PCDF
	Daily Composite	Total Organic Carbon, pH, Temperature
	Weekly Grabs	Petroleum Hydrocarbons Total Suspended Solids Volatile Organics Total Dissolved Solids
	Weekly Composite	Presence of POHCs
Kiln Ash	One Sample per DRE Run	Presence of POHCs, PICs Presence of PCDD, PCDF
CHEAF Media	One Sample per DRE Run	Presence of POHCs, PICs, Presence of PCDD, PCDF
Stack Sample	EPA Modified Method 5; One Sample per DRE Run (Three Samples per Test)	EPA Particulate Emission Rate POHC Emission Rate HCl Emission Rate PIC Identification and Estimated Concentration PCDD, PCDF Emission Rates
	New Jersey Incineration Method; Three Samples/Test	NJ Particulate Emission Rate
	Gas Bag, One per Run	ORSAT for O_2, CO_2
	VOST RCl[e] Sample; Two samples per DRE Run	Chlorinated Organic Emission Rate
	Visual Inspection; Four 6 min. observation per DRE Run, One 30 min. observation per Particulate Run	Opacity (Tests 1, 2, and 3)
Site Monitoring	One Set of Samples per DRE Test	PCBs, TCBs (Test 4 and 5)
Personnel Monitoring	One Set of Samples per DRE Test (6 locations)	PCBs, TCBs (Test 4 and 5)

a - POHC = Principal Organic Hazardous Constituents (test compounds).
b - PCDD = Polychlorinated Dibenzo-p-dioxin.
c - PCDF = Polychlorinated Dibenzofuran.
d - PIC = Product of Incomplete Combustion.
e - VOST RCl = Volatile Organic Sample Train, Chlorinated Organics.

TABLE 4. ANALYTICAL METHODS SUMMARY

ANALYSIS	SAMPLE MATRIX	METHODS SUMMARY
Ash	Diesel & Waste Feed Oils	Thermal Gravimetric Analysis
Density	Diesel & Waste Feed Oils	Gravimetric Analysis
Elemental Analysis	Diesel & Waste Feed Oils	ASTM D-3178,D-3179,E-258,D-3176,D-3177,D-129, D-2361,D-808
HCl	Stack Gas (MM5)[a]	EPA Method 325.3,Specific Ion Electrode, Ion Chomatography
Heavy Metals	Waste Feed Oil	Atomic Absorbtion, Inductively Coupled Argon Plasma
Moisture	Diesel & Waste Feed Oils	Karl Fisher Titration
Opacity	Stack Gas	Visual by Certified Observer
ORSAT	Stack Gas	EPA Method 3
pH	Purge Water	Method 150.1,EPA-600/4-79-020
Particulate, EPA	Stack Gas (M5)[b]	EPA Method 5
Particulate, NJ	Stack Gas	NJ Air Test Method 1 and Incinerator Methods
PCDD,PCDF	Waste Feed Oil	GC/MS[c]
	Make-up & Purge Water, Scrubber Solution	Solvent Extraction, Concentrate, GC/MS
	Kiln & CHEAF Ash	Solvent Extraction, Concentrate, GC/MS
	Stack Gas (MM5)	Solvent Extraction, Concentrate, GC/MS
Petroleum Hydrocarbons	Purge Water	Method 418.1,EPA-600/4-79-020
PIC	Make-up & Purge Water, Scrubber Solution	Solvent Extraction, Concentrate, GC/MS
	Kiln & CHEAF Ash	Solvent Extraction, Concentrate, GC/MS
	Stack Gas (MM5)	Solvent Extraction, Concentrate, GC/MS
POHC	Waste Feed Oil	GC/MS
	Make up & Purge Water, Scrubber Sol'n	EPA Method 617
	Kiln & CHEAF Ash	Solvent Extraction, Concentrate, GC/MS
	Ambient Air (Site & Personnel Monitors)	NIOSH Method P&CAM 244 and S135
	Stack Gas (MM5)	Solvent Extraction, Concentrate, GC/MS
RCL	Stack Gas (VOST)	Thermal Desorption, GC/MS
Total Dissolved Solids	Purge Water	Method 160.2,EPA-600/4-79-020
Total Organic Carbon	Purge Water	Method 415.1,EPA-600/4-79-020
Total Suspended Solids	Purge Water	Method 160.1,EPA-600/4-79-020
Volatile Organics	Purge Water	EPA Method 624

a - Sample collected with EPA Modified Method 5 sample train.

b - Sample collected according to EPA Method 5 sampling procedure.

c - Gas chromatography/mass spectrometry.

TABLE 5. AVERAGE COMBUSTION CHAMBER OPERATING CONDITIONS

Parameter	Test Number 1[a]	2[b]	3[c]	4[d]	5[e]
Rotary Kiln					
Temperature (°C)	900	890	900	980	960
Pressure (kPa)	102	102	102	102	101
Combustion air flow (m^3/min @ STP)	37.1	35.8	35.2	33.7	34.3
Atomization air flow (m^3/min @ STP)	0.7	0.9	0.9	0.9	1.1
Waste flow (kg/hr)	88	92	147	94	98
Diesel fuel flow (kg/hr)	13	15	17	11	14
Injection water flow (L/min)	6.4	5.3	5.7	6.4	5.3
Atomization steam flow (kg/hr)	29	44	45	45	44
Gas residence time (sec)	1.96	2.10	2.06	1.97	2.03
Excess air (%)	104	86	63	92	119
Secondary Combustion Chamber					
Temperature (°C)	1180	1180	1190	1220	1250
Pressure (kPa)	101	102	102	101	101
Combustion air flow (m^3/min @ STP)	27.5	31.8	31.6	22.4	25.5
Diesel fuel flow (kg/hr)	109	132	137	94	110
Gas residence time (sec)	2.22	2.17	2.14	2.43	2.28
Excess air (%)	69	55	42	59	65
O_2 (dry vol.%)	7.54	8.79	8.0[f]	7.21	6.93
CO_2 (dry vol.%)	10.6	9.81	10.0[f]	11.1	11.4
CO (dry vol.ppm)	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
THC (dry vol.ppm)	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
NO_x (dry vol.ppm)	41	52	47	51	51
Combustion effiency (%)	>99.9991	>99.9990	>99.9990	>99.9991	>99.9991

a - Average results from 2 particulate and 2 DRE test runs.
b - Average results from 3 particulate test runs.
c - Average results from 3 particulate and 3 DRE test runs.
d - Average results from 3 particulate and 3 DRE test runs.
e - Average results from 3 particulate and 3 DRE test runs.
f - Average ORSAT analysis at this sampling location.

TABLE 6. TEST 2 AND 3 STACK EMISSIONS

Parameter	Test Number 2[a]	Test Number 3[b]
Waste Feed		
Iron oxide (kg/hr)	1.14	--
Tetrachloromethane (kg/hr)	--	31.8
Dichlorobenzene (kg/hr)	--	43.1
Stack Emissions		
Temperature (°C)	79	79
Flowrate (m^3/min)	239	253
Flowrate (m^3/min @ STP, dry)	106	112
Particulate matter (g/hr)	82.7	316
Particulate matter (mg/m^3)c	22.1	64.9
HCl (ppm)	--	1.6
HCl (mg/m^3 @ STP,dry)	--	2.3
HCl (g/hr)	--	18.3
HCl removal efficiency (%)	--	99.95
Iron oxide (g/hr)	60.8	--
Iron oxide removal efficiency (%)	95	--
Tetrachloromethane (ppb)	--	<0.31
Tetrachloromethane ($\mu g/m^3$ @ STP,dry)	--	<1.9
Tetrachloromethane (g/hr)	--	<0.014
Tetrachloromethane DRE (%)	--	>99.99996
Dichlorobenzene (ppb)	--	0.25
Dichlorobenzene ($\mu g/m^3$ @ STP,dry)	--	1.4
Dichlorobenzene (g/hr)	--	0.011
Dichlorobenzene DRE (%)	--	99.99998
Total RCl ($\mu g/m^3$ @ STP,dry)	--	<63
Total RCl (g/hr)	--	<0.48

a - Average results from 3 particulate test runs.
b - Average results from 3 DRE test runs.
c - Corrected to 7% O_2 in accordance with RCRA.

TABLE 7. TEST 4 AND 5 STACK EMISSIONS

Parameter	Test Number 4[a]	Test Number 5[a]
Waste Feed		
Trichlorobenzenes (kg/hr)	3.8	15.1
Trichlorobenzenes (kg/hr)	0.6	2.9
Aroclor 1260 (kg/hr)	6.6	22.7
Stack Emissions		
Temperature (°C)	78	78
Flowrate (m^3/min)	200	208
Flowrate (m^3/min @ STP,dry)	86.2	90.5
Particulate matter (g/hr)[b]	140	165
Particulate matter (mg/m^3)[c]	35.2	42.7
HCl (ppm)	0.13	0.18
HCl (mg/m^3 @ STP,dry)	0.20	0.26
HCl (g/hr)	1.12	1.50
HCl removal efficiency (%)	99.98	99.99
Trichlorobenzenes (ppb)	< 0.15	< 0.23
Trichlorobenzenes ($\mu g/m^3$ @ STP,dry)	< 1.1	< 1.6
Trichlorobenzenes (g/hr)	< 0.006	< 0.010
Trichlorobenzenes DRE (%)	> 99.9998	> 99.99993
Tetrachlorobenzenes (ppb)	< 0.07	< 0.07
Tetrachlorobenzenes ($\mu g/m^3$ @ STP,dry)	< 0.63	< 0.59
Tetrachlorobenzenes (g/hr)	< 0.004	< 0.004
Tetrachlorobenzenes DRE (%)	> 99.9994	> 99.99985
Aroclor 1260 (ppb)	< 0.15	< 0.23
Aroclor 1260 ($\mu g/m^3$ @ STP,dry)	< 2.1	< 3.3
Aroclor 1260 (g/hr)	< 0.013	< 0.020
Aroclor 1260 DRE (%)	> 99.9998	> 99.99991
Total HCl ($\mu g/m^3$ @ STP,dry)	< 66	< 66
Total HCl (g/hr)	< 0.39	< 0.41

a - Average results from 3 DRE test runs.
b - Average results from 3 separate particulate test runs.
c - Corrected to 7% O_2 in accordance with RCRA.

TABLE 8. SUMMARY OF WASTE WATER ANALYSES

Parameter	Test Week				
	9/12/82	10/18/82	10/25/82	1/4/83	1/10/83
Daily Flow (L/day), Average	16,300	18,800	19,500	21,200	34,900
Total Organic Carbon (mg/L), Average	155	16	7	13	20
Temperature, Range (°C)	52-82	36-75	58-72	32-67	26-57
pH, Range	7.5-10	6.5-11	7-9.5	8.5-9	7.5-8.5
Petroleum Hydrocarbons (mg/L), Average	< 1.0	< 1.0	< 1.0	2.6	1.5
Total Dissolved Solids (mg/L), Average	17,600	14,000	20,500	3,360	12,900
Total Suspended Solids (mg/L), Average	338	65	68	55	36
Volatile Organics (µg/L), Average	86-99	133	< 10	a	< 10

a - Not analyzed.

TABLE 9. SUMMARY OF PERSONNEL MONITORING RESULTS

Location (Station Number)	TCBs[a] on Florisil ($\mu g/m^3$)	TCBs[a] on Charcoal ($\mu g/m^3$)	PCBs as Aroclor 1260 ($\mu g/m^3$)
1	3.8	< 8.9	< 6.2
2	25.7	< 8.9	< 5.0
3	10.4	< 7.0	< 8.8
3a	21.0	--	< 5.0
4	4.7	< 7.1	< 8.6
5	2.0	< 8.4	< 11.0
6	8.1	--	< 11.0

a - Trichlorobenzene or tetrachlorobenzene.

TABLE 10. QUALITY OF CONTINUOUS MONITOR DATA

Gas Component	Precision[a]	Accuracy[b]	Completeness[c]	
			Precision	Accuracy
O_2	1.4%	2.0%	97.5%	89.2%
CO_2	1.1%	1.5%	98.3%	98.3%
CO	4.0%	16.3% (6.5%)[d]	84.3%	87.3%
THC	1.8%	12.7% (4.7%)[d]	95.7%	89.1%
NO_x	6.0%	12.4%	80.9%	83.0%

a - Average precision for all calibrations expressed in terms of the relative standard deviation.

b - Average accuracy for all calibrations expressed as the percentage difference from certified gas standards.

c - Expressed as the amount of valid data obtained compared to the total amount collected according to the following criteria:

5% or 5 ppm, whichever is greater for O_2, CO_2, CO, and THC
10% or 10 ppm, whichever is greater for NO_x.

d - Average accuracy excluding calibrations with standards below 3 ppm.

TABLE 11. CONTINUOUS MONITORING SYSTEM AUDIT GAS ANALYSIS

Mixture	Dates of Analysis	O_2 (%)	CO_2 (%)	CO (ppm)	THC (ppm)
3751	9/14/82 - 1/12/83	9.63	10.8	21.8	21.0
	Certified Analysis	9.53	10.9	19.8	20.6
879	9/14/82 - 1/10/83	7.52	7.63	35.5	36.1
	Certified Analysis	7.37	7.56	45.5	34.6
6251	10/23/82 - 10/29/82	7.90	10.4	9.2	7.3
	Certified Analysis	7.39	10.5	8.8	7.7

List of Captions

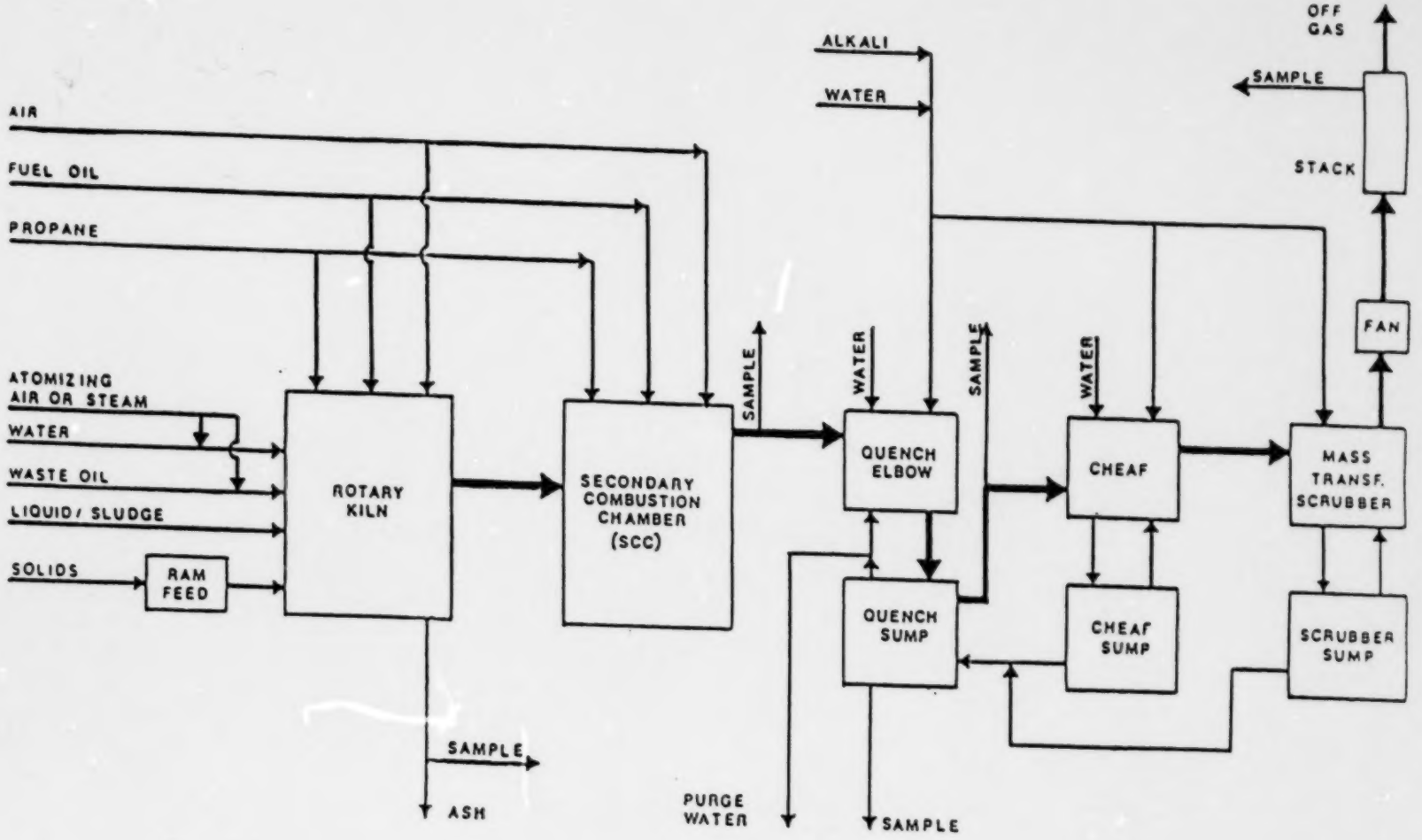
Figure 1. Block Flow diagrams of Mobile Incineration System.

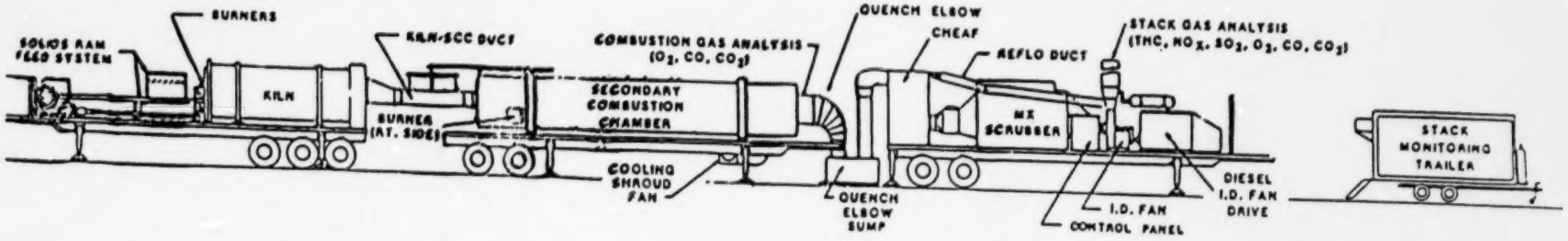
Figure 2. Mobile Incineration System design specifications.

Figure 3. Site layout for Phase III of the trial burn.

Figure 4. Location of personnel monitoring stations.

Figure 5. Site monitoring locations.


AIR
FUEL OIL
PROPANE
ATOMIZING AIR OR STEAM
WATER
WASTE OIL
LIQUID/ SLUDGE
SOLIDS
RAM FEED
ROTARY KILN
SECONDARY COMBUSTION CHAMBER (SCC)
SAMPLE
ASH
ALKALI
WATER
QUENCH ELBOW
QUENCH SUMP
PURGE WATER
SAMPLE
WATER
CHEAF
CHEAF SUMP
SAMPLE
WATER
MASS TRANSF. SCRUBBER
SCRUBBER SUMP
FAN
OFF GAS
SAMPLE
STACK



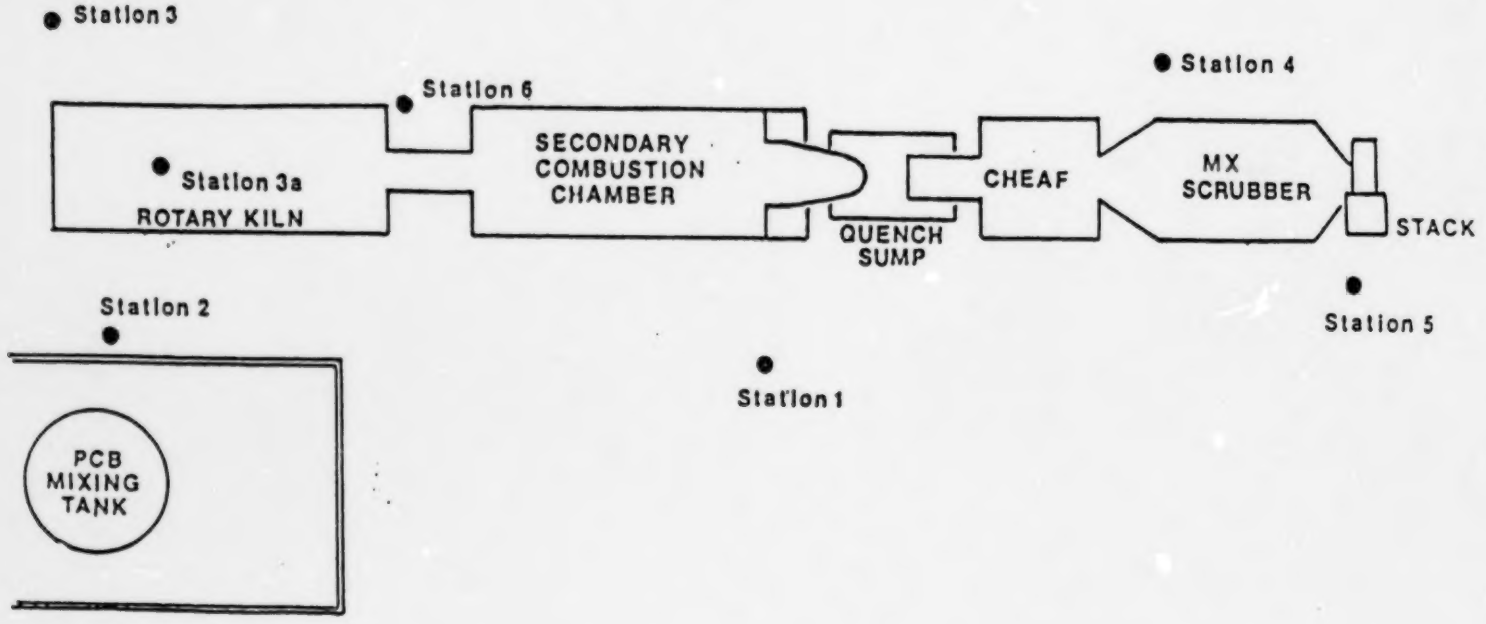
DESCRIPTION

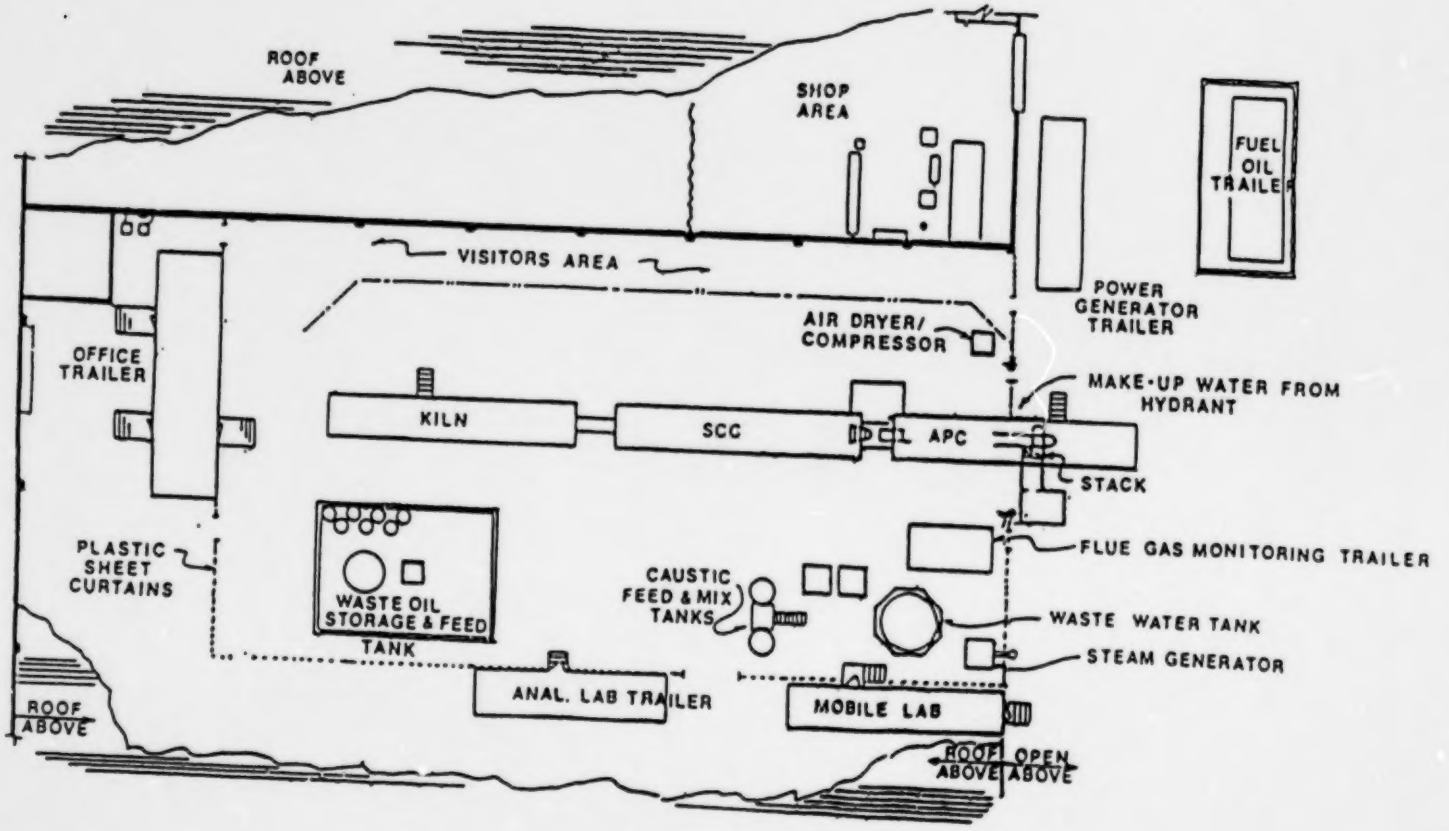
OVERALL WIDTH: 2.4m
OVERALL LENGTH: 45.7m
STACK HEIGHT: 12.2m
OVERALL HEAT DUTY: 1.05 GJ/hr
ELECTRICAL REQUIREMENTS: 100kW

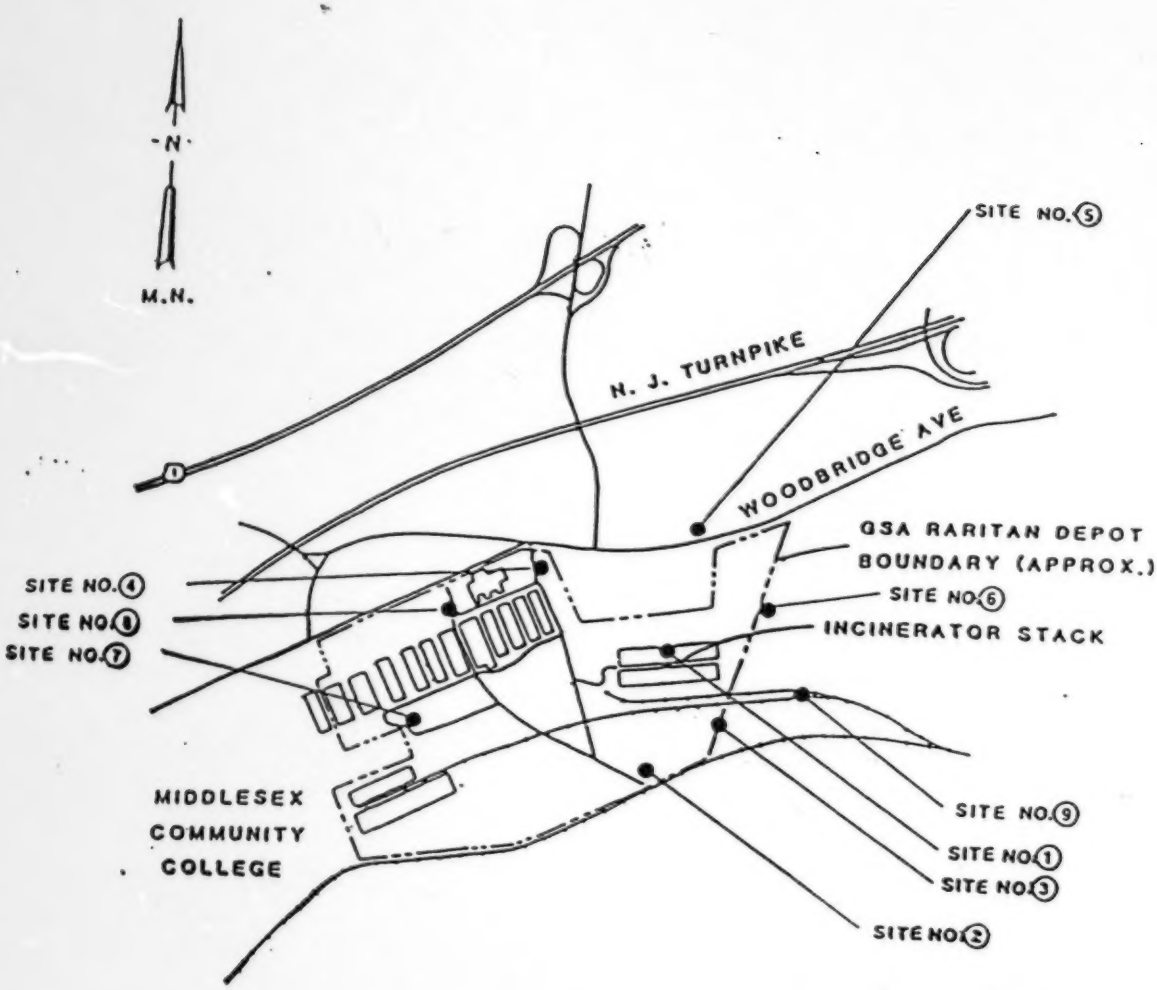
WEIGHT:
TRAILER 1: 24,700kg
TRAILER 2: 29,200kg
TRAILER 3: 15,600kg

DESIGN PARAMETER	KILN	SCC	APC
TEMPERATURE	1000°C	1200°C	80°C
PRESSURE	−1000 Pa	−1500 Pa	−10 KPa
GAS RESIDENCE TIME	2 Sec	2 Sec	
EXCESS OXYGEN	4%	4%	4%
FEED RATES (AT 20 Percent Excess Air):			
AIR	85 m^3/min	34 m^3/min	NONE
FUEL OIL	285 L/hr	150 L/hr	NONE
WASTE SOLIDS	68 kg/min	NONE	NONE
WASTE OIL	227 L/hr	NONE	NONE
WATER	680 L/hr	NONE	+
DISCHARGES:			
ASH	+	NONE	PARTICULATE FILTER MEDIA
WASTE WATER	NONE	NONE	+

+ Dependent upon feed material


Station 3
Station 6
Station 4
Station 3a
ROTARY KILN
SECONDARY
COMBUSTION
CHAMBER
QUENCH
SUMP
CHEAF
MX
SCRUBBER
STACK
Station 2
Station 5
Station 1
PCB
MIXING
TANK


ROOF ABOVE
SHOP AREA
FUEL OIL TRAILER
VISITORS AREA
POWER GENERATOR TRAILER
AIR DRYER/ COMPRESSOR
OFFICE TRAILER
MAKE-UP WATER FROM HYDRANT
KILN
SCC
APC
STACK
PLASTIC SHEET CURTAINS
FLUE GAS MONITORING TRAILER
WASTE OIL STORAGE & FEED TANK
CAUSTIC FEED & MIX TANKS
WASTE WATER TANK
STEAM GENERATOR
ANAL. LAB TRAILER
MOBILE LAB
ROOF ABOVE
ROOF ABOVE
OPEN ABOVE



LEGEND

Site #1 -	Background	
Site #2 -	190° S of Incinerator	
Site #3 -	140° SE	"
Site #4 -	305° NW	"
Site # 5 -	10° N	"
Site # 6 -	60° NE	"
Site # 7 -	255° SW	"
Site # 8 -	285° W	"